

# **SEMICONDUCTOR INTEGRATED CIRCUIT INCLUDING TEST PINS AND METHOD FOR TESTING THEREOF**

## **Field of the Invention**

5       The present invention generally relates to semiconductor integrated circuits and, more specifically, to semiconductor integrated circuits with a plurality of data output pins and methods for testing thereof

## **Background of the Invention**

10       A module construction of a typical TFT-LCD (thin film transistor liquid crystal display) module is illustrated in Fig. 1.

Referring to Fig. 1, an LCD module 1 includes a driving circuit unit 2, an LCD panel 5, and a backlight unit 7.

15       The driving circuit unit 2 has a plurality of gate driver ICs 6A-6C and source driving ICs 6C-6E for driving a panel 5 and printed circuit boards (PCBs) 3 and 4 to which a variety of circuit components such as a timing controller are attached. The LCD panel 5 has a shape where a liquid crystal is inserted into two glasses between substrates. The LCD panel 5 controls amount of white plane light that is incident from the backlight unit 7 to transmit pixels,  
20       serving to display color images in response to each pixel signal voltage inputted from the driving circuit unit 2. The backlight unit 7 has a lamp 8 and a reflex plate 9 and makes plane light having a unit bright from a fluorescent lamp 8 acting as a light source.

As well known to those skilled in the art, the LCD panel 5 includes gate lines and source lines that are intersected in a lattice shape. A pixel is coupled to a gate line and a data line. For example, an LCD panel for a VGA (video graphics array) mode includes 640x480 pixels, and an LCD panel for an XGA (extended graphics array) mode includes 1024x768 pixels. To drive a number of pixels, a gate driver IC and a source driving IC have a number of output pins. The number of these output pins is dependent upon the resolution of the LCD panel 5 that the IC employs. Since an IC cannot have innumerable output pins, the LCD module 1 uses a plurality of ICs that are serially connected. For example, since the LCD panel for the VGA mode has 640 source lines, source driving ICs having 320 output pins must be serially connected by two or a source driving IC having 640 pins may be used.

Generally, a semiconductor integrated circuit is tested by assigning test pins of a test device to all input/output pins in a one-on-one relationship. However, there are required a number of test pins to test integrated circuits having many input/output pins like the foregoing integrated circuits for driving an LCD, i.e., a gate driver IC or a source driving IC.

With scale-up and high definition of LCD panels, the number of pins installed at driving ICs is increasing and a pitch between pins is decreasing. This leads to a difficulty in increasing the number of pins of a test device as pins of the semiconductor integrated circuit increase in number.

## Summary of the Invention

Embodiments of the present invention are to provide semiconductor devices including test pins for sequentially generating output signals in a test mode.

5 Still other embodiments of the present invention are to treat methods for testing semiconductor integrated circuits using a test device including small numbers of test pins.

In some embodiments of the present invention, a semiconductor integrated circuit comprises a plurality of data output pins, a test pin, a data  
10 processing circuit for generating output signals in response to input signals, and an output circuit for outputting the output signals to the data output pins in a normal mode and sequentially outputting the output signals to the test pins in response to a clock signal in a test mode.

In one embodiment, the output circuit controls the output signals not to  
15 be outputted to the data output pins in the test mode.

In some embodiments of the present invention, a semiconductor integrated circuit comprises a plurality of output pins, a test pin, a data processing circuit for generating output signals in response to input signals and transferring the generated output signals to the data output pins, and an  
20 output circuit for sequentially outputting the output signals to the test pins in response to a clock signal.

In one embodiment, the output circuit comprises a shift register operating in response to the clock signal.

In some embodiments of the present invention, a method for generating data in a test mode of a semiconductor integrated circuit with a plurality of data output pins and test pins, comprises determining whether the test mode is activated and sequentially outputting the output signals to the test pins in response to a clock signal in the test mode.

In one embodiment, the output signals are output to the data output pins if the test mode is not activated.

### Brief Description of the Drawings

The foregoing and other objects, features and advantages of the invention will be apparent from the more particular description of a preferred embodiment of the invention, as illustrated in the accompanying drawings in which like reference characters refer to the same parts throughout the different views. The drawings are not necessarily to scale, emphasis instead being placed upon illustrating the principles of the invention.

Fig. 1 is a schematic perspective view of a module construction of a typical thin film transistor–liquid crystal display (TFT-LCD).

Fig. 2 is a schematic block diagram of a circuit of a source driving integrated circuit (IC) according to an exemplary embodiment of the invention.

Fig. 3 is a flowchart showing a control procedure of a channel shifter in the source driving IC illustrated in Fig. 2.

Fig. 4 is a timing diagram showing a clock signal and output signals from a test pin (TP), in accordance with the present invention.

Fig. 5 is a block diagram of a source driving IC according to another

exemplary embodiment of the present invention.

### Detailed Description of the Preferred Embodiment

The present invention will be described more fully hereinafter with  
5 reference to the accompanying drawings, in which preferred embodiments of  
the invention are shown.

Fig. 2 is a block diagram showing an inner circuit of a source driving  
integrated circuit (IC) according to an exemplary embodiment. Referring to  
Fig. 2, a source driving IC 100 comprises data registers 10\_1~10\_n,  
10 multiplexers 20\_1~20\_n/2 and 50\_1~50\_n/2, level shifters 30\_1~30\_n, N-  
decoders 40\_1, 40\_3, ... and 10\_n-1, P-decoders 40\_2, 40\_4, ... and 40\_n,  
amplifiers 60\_1~60\_n, a channel shifter 70, data output pins P1~Pn and test  
pin (TP).

The data registers 10\_1~10\_n receive and store RGB data signals D1-  
15 Dn provided from a host controller (not shown). The multiplexers  
20\_1~20\_n/2 are connected to the data registers, with each multiplexer being  
connected to two data registers as shown, and transmit the data signals stored  
in the connected data registers to level shifters 30\_1~30\_n. For example, the  
multiplexer 20\_1 transfers the data signals stored in the data registers 10\_1  
20 and 10\_2 to level shifters 30\_1 and 30\_2, respectively, and change a direction  
of transferring at a predetermined period. That is, in a first period, a  
multiplexer 20\_1 transfers data stored in a data register 10\_1 to a level shifter  
30\_1 and data stored in a data register 10\_2 to a level shifter 30\_2. In a second

period, multiplexer 20\_1 transfers data stored in the data register 10\_1 to the level shifter 30\_2, and data stored in the data register 10\_2 to the level shifter 30\_1. Operations of the other multiplexers 20\_1~20\_n/2 are performed in the same manner as the multiplexer 20\_1.

5           The level shifters 30\_1~30\_n raise the voltage levels of the data signals transferred from the corresponding multiplexers 20\_1~20\_n up to the voltage level suitable for drive pixels (i.e., a liquid crystal).

          N-decoders 40\_1, 40\_3, ... and 40\_n-1 and P-decoders 40\_2, 40\_4, ... and 40\_n decode the data signals with the levels raised by the corresponding  
10   the level shifters 30\_1~30\_n. That is, the N-decoders 40\_1, 40\_3, ... and 40\_n select and output one of external gradation voltages according to data signals transferred from the corresponding the level shifters 30\_1, 30\_3, ... and 30\_n-1. P-decoders 40\_2, 40\_4, ... and 40\_n select and output one of external gradation voltages according to data signals transferred from the  
15   corresponding the level shifters 30\_1, 30\_3, ... and 30\_n-1.

          The the multiplexers transfer the data stored in the data register 10\_1 and 10\_2 across to the level shifters 30\_1 and 30\_2 to reverse the levels of data signals on the basis of reference voltage and transfer to pixels at a predetermined period. This prevents degradation of the liquid crystal. For  
20   instance, the external gradation voltages provided to the N-decoders 40\_1, 40\_3, ... and 40\_n-1 have the range of 0~7V, and the external gradation voltages provided to the P-decoders 40\_2, 40\_4, ... and 40\_n have the range of 8~15V. Therefore, in a first cycle, data signals D1, D3, ... and D\_n-1 are

decoded into one of the 0 through 7V-gradation voltages by the N-decoders 40\_1, 40\_3, ... and 40\_n-1, data signals D2, D4, ... and D\_n are decoded into one of 8 through 15V-gradation voltages by the P-decoders 40\_2, 40\_4, ... and 40\_n. In second cycle, the external signals D1, D3, ... D\_n-1 are decoded into one of 8 through 15V-gradation voltages by the P-decoders 40\_2, 40\_4, ... and 40\_n, and data signals D2, D4, ... D\_n are decoded into one of 0 through 7V-gradation voltages by N-decoders 40\_1, 40\_3, ... and 40\_n-1.

Each of Multiplexers 50\_1, 50\_3, ... and 50\_n-1 is connected to one N-decoder and one P-decoder, and transfers the gradation voltages provided from the connected decoders to amplifiers 60\_1~60\_n. The multiplexers 50\_1, 50\_3, ... and 50\_n-1 gear with the multiplexers 20\_1, 20\_3, ..., and 20\_n-1. For example, if the multiplexer 20\_1 transfers the data signal D1 stored in the data register 10\_1 to the level shifter 30\_1 and provides the data signal D2 stored in the data register 10\_2 to the level shifter 30\_2, the multiplexer 60\_1 transfers a signal outputted from the N-decoder 40\_1 to the amplifier 60\_1, and transfers a signal outputted from the P-decoder 40\_2 to the amplifier 60\_2. The operation of the other multiplexers 50\_2~50\_n/2 is the same as that of the multiplexer 50\_1 and therefore description thereof will not be repeated.

Signals S1-Sn outputted from the amplifiers 60\_1~60\_n are provided to a pixel of a corresponding LCD panel (not shown) through data output pins P1-Pn acting as source driving signals. In a normal mode, the source driving signals S1-Sn outputted from the amplifiers 60\_1-60\_n are provided to the LCD panel through the data output pins P1-Pn. However, during a test mode,

the source driving signals S1-Sn outputted from the amplifiers 60\_1~60\_n are outputted through a channel shifter 70 to a test pin TP. The data output operations in normal and test modes will be described with reference to FIG. 3, hereinafter.

5           Fig. 3 is a flowchart showing the steps of controlling the channel shifter 70 in the source driving IC 100 of Fig. 2. The channel shifter 70 operates in response to a test mode signal TM. The test mode signal TM has a low level (i.e., logic "0") in a normal mode and has a high level (i.e., logic "1") in a test mode.

10           In step S110, the channel shifter 70 determines whether the test mode signal TM indicates a test mode. When the test mode signal TM indicates the normal mode, not the test mode, the control routine proceeds to step S130.

          In step S130, the channel shifter 70 outputs the source driving signals S1-Sn outputted from the amplifiers 60\_1~60\_n to output pins P1-Pn. For  
15   example, the source driving signal S1 outputted from the amplifier 60\_1 is outputted to the output pin P1 through the multiplexer 70\_1, and the source driving signal S2 outputted from the amplifier 60\_2 is outputted to the output pin P2 through the multiplexer 70\_2. The source driving signals S1~Sn correspond to output pins P1~Pn one-to-one.

20           When the test mode signal TM indicates the test mode, i.e., high level, as a result of determination of the step S110, this control routine proceeds to step S120 in which a first test cycle starts. In step S120, the channel shifter 70 sequentially outputs the source driving signals S1~Sn outputted from the



amplifier 60\_1~60\_n in response to a clock signal CLK.

Fig. 4 is a timing diagram showing a clock signal and a signal outputted to a test pin TP. Referring to Fig. 4, source driving signals S1~Sn outputted from the amplifiers 60\_1~60\_n are sequentially outputted to a test pin TP at each rising edge of a clock signal. That is, the channel shifter 70 outputs, at a first rising edge of the clock signal CLK, the source driving signal S1 outputted from the amplifier 60\_1 to the test pin TP. In this case, the channel shifter 70 does not output the source driving signal S1 outputted from the amplifier 60\_1 to an output pin P1. At a second rising edge of the clock signal CLK, the channel shifter 70 outputs the source driving signal S2 outputted from the amplifier 60\_2 to the test pin TP. In this case, the channel shifter 70 does not output the source driving signal S2 outputted from the amplifier 60\_2 to an output pin P2. In this manner, the channel shifter 70 sequentially outputs the source driving signals S2~Sn outputted from the amplifiers 60\_3~60\_n to the test pin TP in response to from third to nth rising edges of the clock signal CLK.

Accordingly, a test driver 200 includes only one test pin T1 and may test a source drive IC 100 by connecting the test pin TP of the source drive IC 100 to the test pin T1 of the test device 200.

In the above embodiment, the channel shifter 70 operates in response to a test mode signal TM indicating a test/normal mode but may operate in a test/normal mode according whether the clock signal CLK is inputted or not. That is, the channel shifter 70 may operate in a test mode when the clock

signal CLK is inputted but operate in a normal mode when the clock signal CLK is not inputted.

A source driving IC according to another embodiment of the present invention is illustrated in Fig. 5. Unlike the source driving IC 100 of Fig. 2, the source driving IC 300 of Fig. 5 includes a shift register 80 instead of the channel shifter 70 of the source drive IC 100. In Fig. 5 and Fig. 2, the same reference numerals denote the same components.

Referring to Fig. 5, the shift register 80 includes receive and store source driving signals S1~Sn outputted from amplifiers 60\_1 ~60\_n. The shift register 80 outputs the stored source driving signals S1~Sn to a test pin TP in response to a clock signal CLK. The operation of the shift register 80 is the same as that of timing diagram illustrated in Fig. 4. That is to say, the shifter register 80 sequentially outputs the source driving signals S1~Sn stored therein to the test pin TP at each rising edge of the clock signal CLK. For example, the shift register 80 outputs, at a first rising edge of the clock signal CLK, the source driving signal S1 to the test pin TP. The channel shifter 70 outputs the source driving signal S2 to the test pin TP at a second rising edge of the clock signal CLK, and the source driving signal Sn to the test pin TP at an nth rising edge of the clock signal CLK.

Therefore, the test device 200 includes only one test pin T1 and may test the source drive IC 300 by connecting the test pin TP of a source drive IC 300 to the test pin T1 of the test device 200. If the test device 200 includes a plurality of test pins, the test device 200 can test a plurality of semiconductor

chips at the same time.

As described herein, a test device only one test pins is used to test a semiconductor integrated circuit having n output pins. Hence, although there are a number of output pins of a semiconductor integrated circuit, a test device  
5 may test the semiconductor integrated circuit with only one pin. Therefore, it is possible to easily fabricate the test device and to fabricate the same at a low cost. A test device having a plurality of output pins can test a plurality of semiconductor integrated circuits at the same time.

Other modifications and variations to the invention will be apparent to  
10 a person skilled in the art from the foregoing disclosure. Thus, while only certain embodiment of the invention has been specifically described herein, it will be apparent that numerous modifications may be made thereto without departing from the spirit and scope of the invention.

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